Effects of Organic, Organomineral and NPK Fertilizer Treatments on The Nutrient Uptake of Amaranthus Cruentus (L) on Two Soil Types in Lagos, Nigeria

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Abstract

The macronutrient uptake of *A. cruentus* under two soil types: Ikorodu (orthic Luvisol) and Lagos state university LASU) Ojo campus, (Dystric Fluvisol) were investigated under field conditions. Eight fertilizer treatments (1) control (no fertilizer), (2) pacesetter’s Grade B (PGB) 100%, (3) PGB + NPK (75:25), (4) PGB + NPK (50:50), (5) Kola Pod Husk (KPH) 100%, (6) KPH + NPK(75:25), (7) KPH + NPK(50:50) and (8) NPK(100%) were tested at first planting. Residual effects of the fertilizers were assessed in the second and third planting periods. The experiment was arranged in a randomized complete block design in four replications. Data were analyzed using ANOVA Test. Due to the high N status of the soil in Ikorodu (sandy clay loam) its uptake was significantly ($p<0.05$) higher (87.1%) than that of LASU. The KPH and PGB had the highest potential in A. cruentus production. At Ikorodu site, KPH + NPK (75:25) had the nutrient uptake while at LASU, PGB + NPK (75:25) was optimum. KPH + NPK (75:25) gave highest N, P, K, Ca and Mg uptake in *A. cruentus*

Keywords: Orthic luvisol, Dystic fluvisol, Dry matter yield, macronutrients

Introduction

The constraints of small scale farmers in increasing crop yield in Nigeria include, small farm size and fertilizer supply [1]. Research result indicated that availability of fertilizer has direct effect on cost of fertilizer Chandra and Singh. [2]. There is a need for cheaper alternative that can make fertilizer more available to farmer. In most cases, Nigerian farmers’ access to fertilizer in vegetable growing season is limited by fund [1], Scarcity and late distribution are the major problems to the optimum production of vegetables. It is therefore necessary to source for locally available, cheap and environmental friendly materials that can be used solely or integrated for vegetable production. Organic materials have advantages of being environmental friendly as reported by Yusoff [3]

Organic materials are capable of promoting crop growth and increasing yield by improving soil physical, chemical and biological properties [4]. Organic fertilizers improve the physical properties of the soils, helps the soil to maintain better tilth and increase water holding capacity [5].Organic fertilizer supplies both major and minor plant nutrients. The supplied nutrient can substitute for appreciate amounts of inorganic fertilizer [6]

Amaranthus cruentus species are extensively cultivated; and due to their early maturity and ability to survive when grown with other arable crops, remains the most preferred crop by many farmers for timely revenue generation. Amaranthus cruentus are produced under different cropping systems in home gardens, farms, inland valleys (*fadamas*) and peri-urban garden. About 30-40% of total *A. cruentus* production by individual farmers is used for family consumption while the rest are marketed [7]

Amanrantus cruentus contain relatively high amount of Fe and Ca when compared with other vegetables. Its leaves are eaten as vegetable when boiled. It is a hebecaceous plant used for culinary purposes. It is used to improve the quality of soups and also for its dietary potentials. Fresh vegetables are of great importance in the diet because of the presence of vitamins and mineral salt [8]the nutritive composition of both gains and vegetable amaranth has been extensively studied [9] have been tested for their conversion into fertilizers. Te organic material include the following: farm residues, green manure, by product of agriculture, forestry and fisheries, municipal wastes, animal waste, industrial waste and factory affluent and night soil and urine [10].

This study was set up to investigate the effect of two organic materials: Kola pod husk and pacesetter Grade B organic fertilizer used alone or in combination with NPK 15:15:15 on the nutrient uptake of *A. cruentus* in two ecological areas of Lagos State.

Materials and Methods

The study area:

The experiments were sited in two locations, namely Ikorodu farm settlement and Lagos State University (LASU) Ojo Campus. The two locations belong to two soil types Ikorodu (Orthic Luvisol) and LASU (Dystric fluvisol) [11]. Ikorodu is located in the rain forest zone of west, Nigeria (6^o37N; 3^o53’E) and the altitude is about 15.50 meters above sea level; LASU is located at Ojo in Badagry Division of Lagos State of Nigeria. It is located at the swamp forest of southwestern Nigeria (6^o27’N; 3^o130’E and the altitude is above the sea level). The dominant vegetation of Lagos State is the swamp forest consisting of the fresh water and mangroves, swamp forest both of which are influenced by bi-modal rainfall pattern with peaks in July and October ranges from 1584.5 to 1605.91mm.

Sample Collection:

Organic materials used were Kola pod Husk (KPH) and pacesetter Grade fertilizer (non fortified sorted city refuse waste plus cow dung, PGB). The KPH was obtained from the Kola processing unit of Cocoa Research Institute of Nigeria (CRIN) and PGB fertilizers was obtained from the Pacesetter organomineral Fertilizer Plant at Bodija, Ibadan. The KPH was oven dried at 70^{o}C to constant weight and milled to pass through 2mm sieve before analysis. The test crop was *Amaranthus cruentus* variety (ED 2/1019) early maturing type. The optimum N requirement (67.5kg N ha.^{1}) for Amaranthus cruentus [12] was used to amend the organic fertilizer at a ratio of 3:1, organic for 75:25 mixture and at 1:1 organic for 50:50 mixture and LASU. In these sites, eight fertilizer treatments were used; (i) control (no fertilizer), (ii) KPH (100%), (iii) KPH+NPK (75:25), KPH+NPK (50:50), (v) PGB (100%) (vi) PGB + NPK (75:25), (vii) PGB+NPK (50:50), (vii) NPK (100%).

Experimental Layout:

The experiment was laid out in a randomized complete block design (RCBD) with four replications, per location. *Amaranthus cruentus* seedlings were raised and transplanted to seedbeds at a spacing of 10cm x 20cm. Harvesting was done at 6 weeks after transplanting. The experiment was repeated without any fertilizer application at the second and third planting.

Chemical Analysis:

Pre-cropping chemical analysis of the experimental soil was carried out before bed preparation and repeated at the first, second and third harvest to determine the nutrient status of the soil. The soil samples were air dried, crushed and sieved to pass through 2mm sieve after which they were analyzed for total N using macro kjedahl procedure as described by Jackson [13]described by Bray and Kurtz [14] exchangeable acidity was determined by the titration method as outlined in IITA manual series[15]. Exchangeable K, Ca and Mg were determined by extraction with 1M ammonium acetate at pH7.0 and the amount of K and Ca in the filtrate was determined using a corning Flame Photometer with appropriate filter. While Mg was determined using a Perking-Elmer Atomic Absorption Spectrophotometer (AAS). Effective caution exchangeable capacity (ECEC) of the soil samples was determined by summation of cations and the exchangeable acidity together.

Chemical Analysis of Plant:

The plant material were wet digested by weighing 0.2g of each materials into a separate 50mL digesting tube and adding 30mL of hydrogen peroxide under fume sulphuric acid and 20mL of hydrogen peroxide under fume cupboard. The bottles were set up on heating mantle, digests were cooled and each transferred to separate 100mL volumetric flask and made up to mark distilled water and then nitrogen was determined using a Technicon-Auto-Analyser. Dry ash method was used for other elements. The plant materials (0.2g) were weighed into labeled crucibles, ashed furnace cooled and dissolved with 5mL of 4% HC1 and leached with distilled water into 100mL conical flasks and analyzed for phosphorus using Vanado-Molybdate method colorimetrically; potassium and calcium were by flame photometer, while the magnesium was through Atomic Absorption Spectrophotometry, using appropriate filters.

The nutrient uptake was calculated using the formula:

Nutrient Uptake = Dry matter yield (kg) x nutrient content (%)

Data Collection: Data were collected on the plant dry matter yield; nutrient concentration and nutrient uptake were collected.

Data Analysis:

Analysis of variance was carried out on data collected and means separated using Ducan's multiple range test.

RESULTS

The soil at Ikorodu was less acidic pH (6.1) compared with that of LASU (pH 5.3). In addition, the soil at Ikorodu had higher organic carbon and N content compared with LASU. The available P was similar at the two locations. Exchangeable base at Ikorodu was higher than Ojo while exchangeable acidity at LASU was higher than Ikorodu. However the micronutrients content were similar.

The Grade B organic fertilizer contained more N than KPH. The carbon content in PGB was less than that of KPH. The P and K in KPH were more than that of PGB. Calcium, Mg and micronutrient contents of the two fertilizers were similar.

Effects of Different fertilizers on some macronutrients Uptake of A. Cruentus at first cropping at Ikorodu and LASU:

A cruentus planted at Ikorodu generally had higher uptake than that of LASU (Table 1). At Ikorodu, the soil treated with KPH + NPK (75:25) mixture significantly ($P<0.05$) increased N uptake (22.36g plant^{-1}) by *A. cruentus* compared with all other nutrients.

At LASU, the soil treated with 100% PGB and PGB +NPK (50:50) mixture increased significantly ($P<0.05$) N uptake (39.22g plant^{-1}) compared with other treatments. The 100% KPH significantly increased ($P<0.05$) P uptake at Ikorodu. At LASU, the highest uptake was obtained with PGB + NPK (50:50) mixture. At Ikorodu, KPH + NPK (75:25) mixture increased K uptake significantly ($P<0.05$) while PGB + NPK (50:50) mixture increased K significantly at LASU. At Ikorodu KPH+NPK (75:25) mixture enhanced Ca uptake than other treatments, it was PGB + NPK (50:50) mixture that increased Ca uptake at LASU. At Ikorodu, control plots had the least Mg (0.07mg plant^{-1}) while the plots treated with KPH + NPK (75:25) mixture had the highest Mg

(10.8mg plant^{-1}). At LASU, it was treatment PGB + NPK(50:50) mixture that had the highest Mg uptake (30.22mg plant^{-1}) than other treatments.

Residual effects of different fertilizers on some macronutrient uptake of A. cruentus at second field cropping at Ikorodu and LASU:

At the second planting, N uptake by *A. cruentus* was generally higher at Ikorodu than LASU. The KPH+NPK (75:25) and (50:50) mixtures enhanced the uptake of N uptake with corresponding values of 266 and 246 mg plant^{-1} respectively at Ikorodu (Table 5). At LASU, 100% PGB, PGB + NPK (75:25) and (50:50) mixture increased significantly (P<0.05) N uptake by 83.4 and 76.6 mg plant^{-1} respectively. The KPH+NPK (75:25) and (50:50) mixtures enhanced the uptake of P by 54.4 and 41.1mg plant^{-1} respectively at Ikorodu. At LASU, PGB previously treated soil produced significantly (P<0.05) more P uptake (16.4, 18.1 and 15.1mg plant^{-1}) than other treatments (Table 2). At Ikorodu, 100% KPH and PGB previously treated soil increased significantly (P<0.05) K uptake by *A. crucent.* PGB applied alone, organomineral alone and PGB combined with organmimeral fertilizer increased P by 40.4, 47.3 and 40.2 mg plant^{-1}. At Ikorodu KPH + NPK (50:50) mixture previously treated soil significantly (P<0.03) increased Ca uptake (117 mg plant^{-1}) compared with control and NPK treated soil. At LASU, soil previously treated with PGB, organic and organomineral fertilizer, significantly (P<0.05) enhanced Ca uptake by *A. cruentus* (48.3, 62.3 and 54.4 mg plant^{-1}) than other treatments. At Ikorodu, soil previously treated with KPH + NPK (75:25) mixture significantly (P<0.05) enhanced Mg uptake (141.8mg plant^{-1}) than where 100% NPK and PGB were previously applied. At LASU soil previously treated with PGB + NPK (75:25) (50:50) mixture significantly (P<0.05) increase Mg uptake (45.0 and 36.5mg plant^{-1}) than other treatments except 100% PGB.

Residual Effect of Different Fertilizer on Some Macronutrient Uptake of A. Cruentus at Third Field Cropping at Ikorodu and LASU:

Soil that was previously treated with 100%KPH and KPH + NPK(75:25) mixture, significantly (P<0.05) increased N uptake by 129 mg plant^{-1} at Ikorodu (129 and 125mg plant^{-1}) than other treatments at Ikorodu (Table 3). At LASU, soil previously treated with PGB + NPK (75:25) mixture significantly (P<0.05) enhanced N uptake (70.1mg plant^{-1}) than other treatments. Generally, that of LASU at third cropping, significantly (P<0.05) increased P uptake (29.7mg plant^{-1}) with the soil previously treated with 100% KPH and KPH+NPK (75:25) mixtures at Ikorodu. Soil that previously received PGB+NPK (75:25) mixture significantly (P<0.05) increased P uptake (4.3 mg plant^{-1}) mixture significantly (P<0.05) increased K, Ca and Mg uptake (19.8, 41.2 and 37.5 mg plant^{-1}) than other treatment except PGB (100%) and PGB + NPK (50:50) mixtures. At the third cropping of *A. cruentus* generally, KPH + NPK (75:25) mixture significantly (P<0.05) increased macronutrients uptake than other treatments at Ikorodu and LASU respectively.

Table 1: Effect of different fertilizers on yields and some macronutrients uptake of A. cruentus at 6 WAS at first field cropping at Ikorodu and LASU soils.

	Ikorodu Nutrients uptake (mgkg^{-1})					LASU Nutrients uptake (mgkg^{-1})				
Treatments	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Control	4.39d	0.39c	3.19d	155d	1.33d	0.13d	0.05d	0.15d	0.19d	0.07e
PGB (100%)	9.55c	3.77b	11.49c	5.47b	3.77bc	22.48b	68.86ab	30.68b	54.85ab	16.85b
PGB+NPK (75:25)	15.88bc	2.50b	28.76ab	3.93cd	3.95bc	28.09ab	7.85ab	40.25ab	69.13ab	21.70at
PGB+NPK (50:50)	17.40b	2.06b	24.18b	6.10ab	2.00c	39.22a	12.09a	56.73a	96.72a	30.22a
KPH (100%)	15.25bc	6.36a	33.52a	8.80ab	6.80b	14.86b	3.99b	19.46bc	33.06b	10.47e
KPH+NPK (75:25)	22.36a	6.25a	34.66a	10.60a	10.8a	27.17ab	7.78ab	27.74b	45.6ab	17.95b
KPH+NPK (50:50)	15.63bc	5.52ab	25.44b	2.17bc	6.69b	22.32b	5.70ab	21.27bc	25.21b	7.07ed
KPH (100%)	8.93c	2.04ab	5.35cd	1.91c	2.85c	2.63c	1.27c	4.02c	2.76c	1.36d

Means having the same letter(s) in the same column are not significantly different at 5%

KPH = Grade B: KPH = Kola pod husk; NPK 15:15:15

Table 2: Effect of different fertilizers on some macronutrients uptake of A. cruentus at second field cropping at Ikorodu and LASU

	Ikorodu Nutrients uptake (mgkg^{-1})					LASU Nutrients uptake (mgkg^{-1})				
Treatments	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Control	3.49d	11.9c	32.4c	36.5b	16.8c	9.0d	0.2d	1.0e	1.3d	0.5e
PGB (100%)	80.2c	26.5c	77.5ab	80.9ab	35.4bc	83.4a	16.4ab	40.5ab	48.3ab	13.5b
PGB+NPK (75:25)	89.3bc	28.5b	87.0ab	93.5ab	88.6ab	89.3a	18.1a	47.3a	62.3a	45.0a
PGB+NPK (50:50)	145b	24.8b	77.3ab	82.8ab	79.3ab	76.6ab	11.5ab	40.2ab	54.4ab	36.5ab
KPH (100%)	172ab	29.9b	85.5ab	96.7ab	90.2ab	33.2bc	1.8c	7.9c	10.4b	5.3c
KPH+NPK (75:25)	246a	54.5a	91.4a	97.7ab	141.8a	46.1b	1.3c	2.9cd	8.3bc	5.3c
KPH+NPK (50:50)	266a	41.1ab	97.6b	117a	109.5ab	34.5bc	1.4c	15.8b	9.7b	6.6c
KPH (100%)	44.8d	32.7ab	47.8b	45.2b	20.5b	22c	1.0c	5.5d	5.2d	3.6cd

KPH = Grade B: KPH = Kola pod husk; NPK 15:15:15

Means having the same letter(s) in the same column are not significantly different at 5%

Table 3: Effect of different fertilizers on some macronutrients uptake of A. cruentus at third field cropping at Ikorodu and LASU

	Ikorodu Nutrients uptake (mgkg-1)					LASU Nutrients uptake (mgkg-1)				
Treatments	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Control	5.0c	10.8d	8.3c	31.3c	15.2d	2.0d	0.1d	0.8d	0.9d	0.2e\
PGB (100%)	4.10b	17.8b	53.5b	54.4b	49.5b	50.7ab	2.4b	11.7ab	22.7ab	4.4b
PGB+NPK (75:25)	44.3b	16.2b	56.8b	67.0ab	60.2ab	70.1a	4.3a	19.8a	14.2a	37.5a
PGB+NPK (50:50)	53.1b	23.4ab	67.7ab	72.1ab	66.5ab	53.0ab	2.5b	17.5ab	21.4ab	19.2a
KPH (100%)	129.0a	27.9a	87.5a	94.6a	85.1a	17.0c	0.7c	5.3bc	6.1bc	5.7c
KPH+NPK (75:25)	90.0ab	29.7a	89.3a	90.9a	141.8a	42.0b	0.9c	7.2b	8.2b	7.7b
KPH+NPK (50:50)	126.1a	21.6ab	91.2a	103.2a	109.5ab	22.0bc	0.8c	6.4b	6.9bc	6.2bc
KPH (100%)	7.1c	13.5c	10.2c	32.6c	20.5b	13.1c	0.5c	4.2c	4.0c	1.6d

Discussion

The higher increase in soil N at KPH + NPK (50:50) mixture compared with PGB + NPK) (50:50) mixture at Ikorodu and that of LASU confirmed the earlier report of Agboola [16] that nitrate-nitrogen is liberated when plant residues are ploughed into the soil and crop could utilize this for their growth. This resulted in high N uptake observed in *A. cruentus* when KPH was applied than PGB at Ikorodu [17].

Fertilizer treatment enhanced higher N, P, K Ca and Mg uptake by *A. cruentus* than control on the two soils on the field at first cropping. There was an increase in N, P, K, Ca and Mg uptake by plant when KPH and PGB as organic and organomineral fertilizer than 100% NPK and control. This confirmed the report of OJeniyi *et al.* [18, 19] on positive response of macronutrients uptake by vegetables when market wastes and cocoa pod husk where applied to the soil compared to when inorganic fertilizer was applied.

The KPH source of organic and organomineral fertilizer proved better than PGB source in enhancing K Ca and Mg uptake by *A. cruentus* at both locations probably due to a reflection of the native soil K, Mg and Ca contents at both locations. This agreed with the report of Prokochev [20] that the more the soil K level, the more its absorption in any indiscriminate manner.

The sustainable growth and yield recorded over a period of time by KPH + NPK (50:50) and (75:25) mixtures at second and third cropping may be due to higher N, P, K, Ca and Mg uptake [21].

The availability of P in the soil at the end of the first and second cropping where KPH + NPK and PGB + NPK (50:50) and (75:25) mixtures were previously applied might result to other elements being made available for growth and yield of *A. cruentus*. This observation confirmed the earlier work of Ojo and Olufolaji [22] that the presence of P in the soil increase yields and quality of *A. cruentus*.

Conclusion

Eight fertilizer treatments (1) control (no fertilizer), (2) pacesetter's Grade B (PGB) 100%, (3) PGB + NPK (75:25), (4) PGB + NPK (50:50), (5) Kola Pod Husk (KPH) 100%, (6) KPH + NPK(75:25), (7) KPH + NPK(50:50) and (8) NPK(100%) were tested at first planting. Residual effects of the fertilizers were assessed in the second and third planting periods. Due to the high N status of the soil in Ikorodu (sandy clay loam) its uptake was significantly ($p<0.05$) higher than that of LASU. The KPH and PGB had the highest potential in A. cruentus production. At Ikorodu site, KPH + NPK (75:25) had the highest nutrient uptake while at LASU, PGB + NPK (75:25) was optimum. KPH + NPK (75:25) gave highest N, P, K, Ca and Mg uptake in *A. cruentus*

Plant nutrient (N, P, K Ca and Mg) uptake increased at both locations. Nutrients uptake was more enhanced at Ikorodu than LASU. Integrated application of organic materials and minerals fertilizer could be used for optimum production of amaranthus.

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